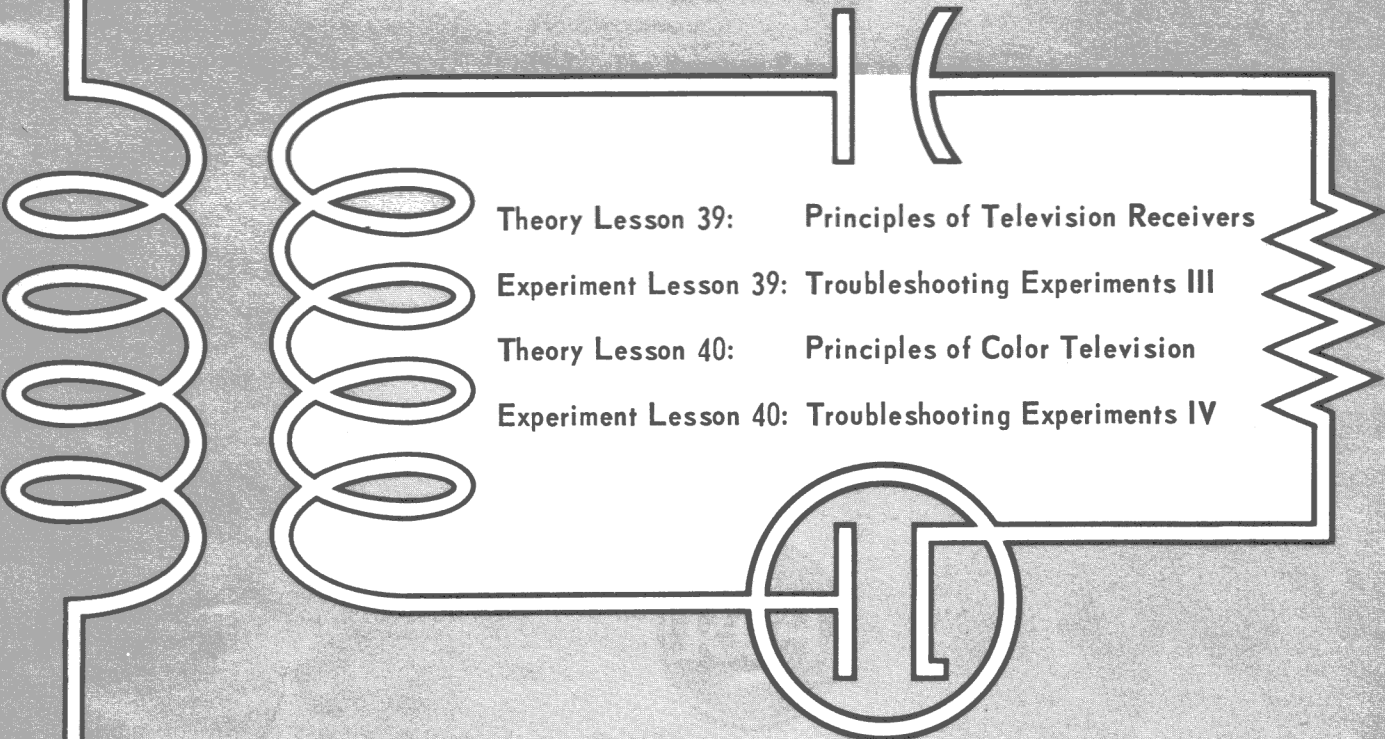


ELECTRONIC FUNDAMENTALS



Theory Lesson 39: Principles of Television Receivers

Experiment Lesson 39: Troubleshooting Experiments III

Theory Lesson 40: Principles of Color Television

Experiment Lesson 40: Troubleshooting Experiments IV

RCA INSTITUTES, INC.

A SERVICE OF RADIO CORPORATION OF AMERICA

New York,

N. Y.



ELECTRONIC FUNDAMENTALS

THEORY LESSON 39

PRINCIPLES OF TELEVISION RECEIVERS

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The Receiver Process**
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Theory Lesson 39

INTRODUCTION

This lesson is intended to teach you how a television receiver works. The operation of a television receiver depends upon basic electronic principles that you have learned during your study of radio. You will find out just how the basic principles you have learned apply to television receivers.

39-1. MAKE UP OF THE SIGNAL - THE RECEIVER PROCESS

A television receiver (Fig. 39-1) produces a motion picture and sound to go with the picture. It receives the signal transmitted by a television broadcasting station and

processes the signal to produce picture and sound. A study of how the television receiver operates is a study of how it processes the incoming signal. The incoming signal is more complicated than the radio signals that you have studied. Therefore, in order to follow the explanation of how the receiver operates, you must have a clear idea of the makeup of the incoming signal.

In Theory Lesson 38, you learned that the signal coming in at the receiver antenna consists of a picture carrier, and a sound carrier. The sound carrier brings the sound *information* from the television station and the picture carrier brings picture and synchronizing information. Figure 39-2 shows the picture carrier signal amplitude modulated with picture information and synchronizing (sync) information. Also the figure shows the sound signal, which carries sound information by means of frequency modulation. Thus, you can see all the signal characteristics that the receiver makes use of to process the signal. The diagram has three dimensions, like a box. One dimension represents frequency. Another dimension represents amplitude or instantaneous signal voltage. The third dimension represents time.

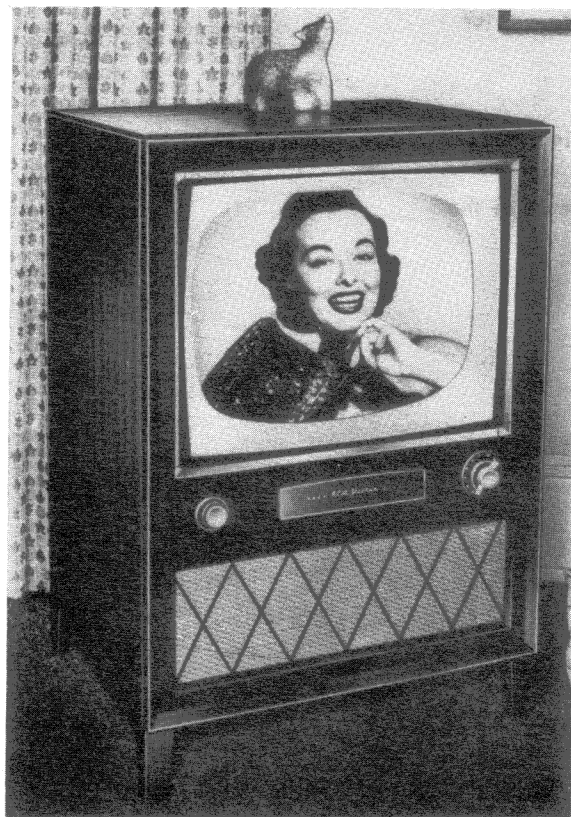


Fig. 39-1

Signal Related to the Receiver. Let us consider how the signal characteristics shown in Fig. 39-2 are related to what happens in a television receiver. The receiver must select the signal of the desired broadcast station and reject those of all other TV stations. This is accomplished by superheterodyne action, aided by r-f preselectivity, just as in the case of a superheterodyne radio receiver. Just as do radio broadcast stations, each television station puts out picture and sound carrier signals which are at different frequencies than those of other stations within range of the receiver. Each station fits within a frequency channel,

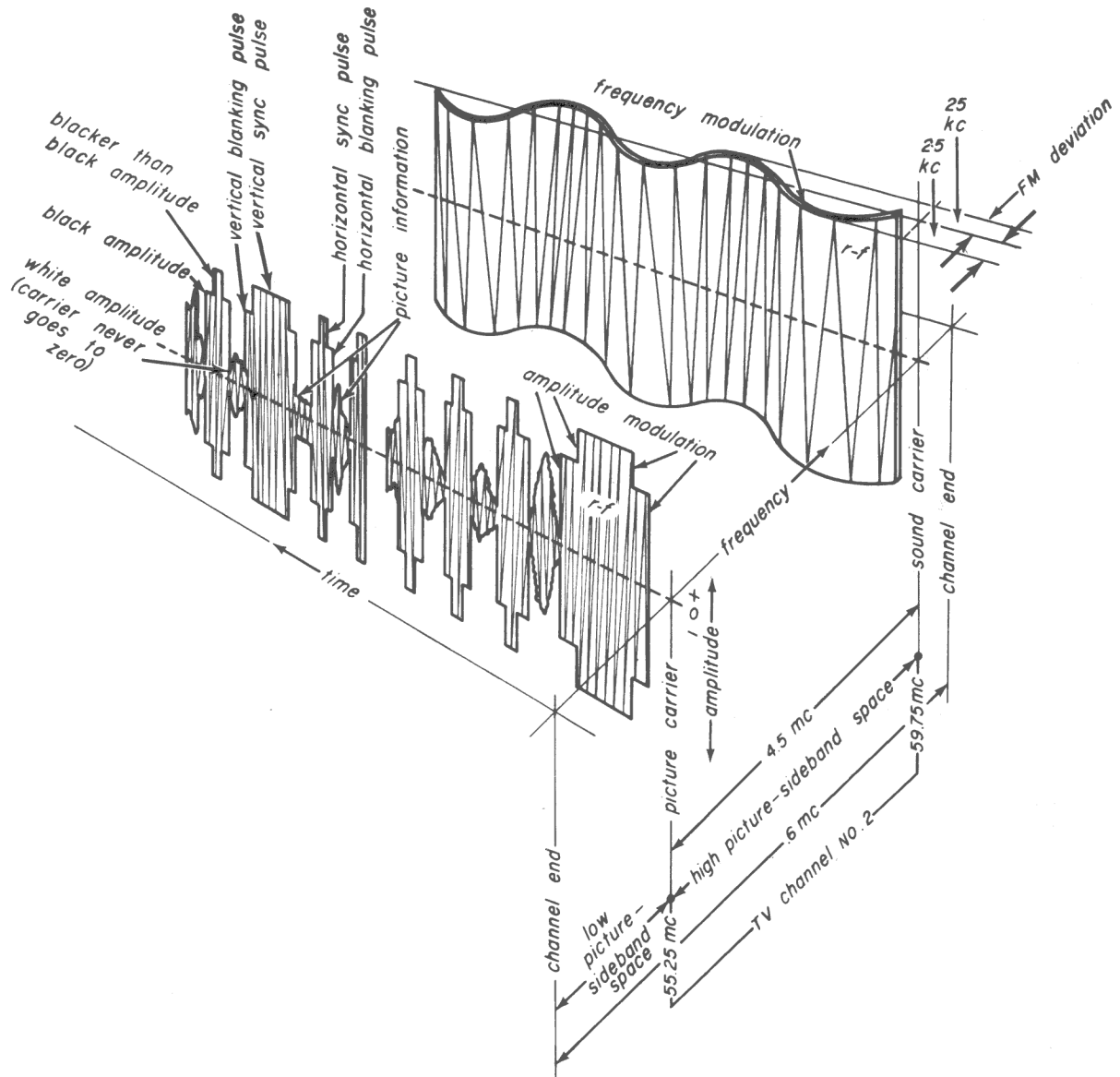


Fig. 39-2

which, as shown in Fig. 39-2, is 6 mc wide. The frequency channel includes both the picture and the sound signals. As shown in Fig. 39-2, the picture and sound frequencies officially assigned to *Channel 2* are 55.25 mc and 59.75 mc, respectively. Any stations licensed by the FCC to operate on *Channel 2* must send out their picture and sound information on these radio frequencies.

The receiver separates the sound signal from the picture signal so that sound can be routed to the loudspeaker and the picture can be routed to the picture tube. This is

possible because the frequency of the incoming picture carrier signal differs from the sound carrier signal by exactly $4\frac{1}{2}$ mc, as shown in Fig. 39-2. The two possible methods that a receiver can use to separate picture and sound depend upon the $4\frac{1}{2}$ -mc difference characteristic of picture and sound in the incoming signal. These two methods will be described later in this lesson. One is called the *split sound* method, and the other is called the *intercarrier sound* method.

The $4\frac{1}{2}$ -mc space shown between the picture and sound carriers in Fig. 39-2 is not empty. It is occupied by the upper sidebands

of the amplitude-modulated picture carrier. There is room enough in this $4\frac{1}{2}$ -mc space for the maximum number of sidebands that might result from modulating the picture carrier with picture information. However, this space is not always filled in, because under broadcast conditions, the maximum possible number of sidebands is not produced. The number and the frequency of sidebands produced depends upon the instantaneous frequency of the video (picture) signal that is modulating the carrier at any given time. The instantaneous video frequency depends in turn upon the size of the corresponding picture element. For example, a small picture element might be represented by an instantaneous modulation frequency of 3 mc. It would cause a momentary sideband signal to occur 3 mc above the picture carrier (within the $4\frac{1}{2}$ -mc space between picture and sound carriers). For Channel 2, this random sideband would occur at 58.25 mc.

Since a modified form of single-sideband transmission is used for picture transmission, some of the lower picture sidebands are not sent out. Therefore, the frequency space provided for the lower sidebands can be smaller than the space provided for the upper sidebands. The *vestigial* (remaining) lower sidebands fall in the space extending from the picture carrier frequency to the lower end of the 6-mc channel.

The receiver demodulates the signal—it removes the modulation content of picture and sound from the r-f carriers. Figure 39-2 shows that picture information is an amplitude modulation and that sound information is a frequency modulation of the incoming signal. From your knowledge of basic radio theory, you know immediately that the receiver circuit must include a discriminator or ratio detector to demodulate the incoming FM sound signal and a detector to demodulate the incoming AM picture signal.

After the sound signal has been demodulated, it is an audio signal ready for application to the audio amplifier of the TV receiver. From the audio amplifier, the audio signal goes to the loudspeaker, just as in the case of a radio receiver.

After the picture signal has been demodulated, it is in the form of the standard composite video signal—the form of the amplitude modulation envelope shown in the picture carrier in Fig. 39-2. The composite video signal includes vertical and horizontal sync pulses as well as picture information signal and blanking signal.

The composite video signal must be broken up, because different parts of it go to different circuits in the TV receiver. Picture and blanking signals are sent to the picture-tube (kinescope) control grid, where both of these signals control the brightness of the moving spot of light on the viewing screen. The vertical and horizontal sync pulses go separately to the scanning circuits of the receiver in order to lock the movement of the spot of light (the spot is the effect of the beam on the screen) in time with the scanning spot in the camera back at the TV station. So the sync pulses must be separated from the picture signal of the demodulated composite video signal. This is possible because the sync is maintained at a higher amplitude (signal voltage level) than is ever attained by picture or blanking signal. The amplitude of the blanking pulses is just right to completely blank (black out) the spot of light (that is retracing during the time of blanking). The sync pulses ride above the blanking pulses at a greater amplitude, called *blacker than black*. At this level, they would darken the spot of light still more, were it not that the spot is already blacked out by action of the blanking pulses. Thus, the sync pulses produce no visible effect upon the picture. Therefore, sync pulses can be applied to the picture tube control grid along with blanking and picture signal without doing any harm, but the sync pulses must be separated from the remainder of the composite signal for application to the deflection circuits. It would not be all right to apply picture and blanking signals to the deflection circuits; if they were, the receiver scanning would be thrown out of synchronism with the camera. Sync is separated from video by receiver circuits that pass signals at a high-amplitude level and reject signals at a lower amplitude level. Although you are not familiar with these circuits, sometimes called *clipper* cir-

uits, they work something like the limiter circuits that you have studied. Limiters clip off and discard signals above a predetermined signal-amplitude voltage level, retaining lower level signals. The clippers clip off and retain signals above a predetermined voltage level, discarding lower level signals.

After separation from the picture and blanking signals, the vertical and horizontal sync pulses which control vertical and horizontal deflection must be separated from each other. This is possible because the time duration of the standard vertical pulse is much longer than the time duration of the standard horizontal pulse. These pulses are separated in the receiver by the combined action of an integrating network and a differentiating network. An integrating network delivers an output pulse if a pulse of long duration is applied to its input but not if a pulse of short duration is applied. A differentiating network delivers an output pulse corresponding to its input pulse if a pulse of short duration is applied, but it shortens the time of any applied long pulse, thereby making the long pulses correspond to short pulses — destroying the distinctive identity of the long pulses.

Although you are not familiar with differentiating and integrating networks, they are resistance-capacitance networks and their action depends upon RC time constants, which you understand.

39-2. THE RECEIVER PROCESS IN BRIEF

Let's go over the chain of events in a receiver with the aid of the *flow sheet* diagram in Fig. 39-3. A flow sheet is a diagram used to show at a glance where things start, where they go, and how they get there. (Flow sheets are often used to describe industrial processes such as the refining of iron ore and also to describe the distribution of authority within organizations such as large business establishments or a government agency.)

Our flow sheet shows that the signal coming into a receiver consists, after it has been separated from the signals of all other stations, of picture and blanking and

vertical and horizontal sync in the form of modulation together with sound in the form of modulation. The picture and sync signal is separated from the sound signal by either the split-sound or intercarrier method; both signals remain in modulation form. Then both signals are demodulated. The full video signal goes down to the kinescope grid. The audio signal needs no further processing and goes to the loudspeaker. Meanwhile, the sync pulses are extracted from the video signal by clipping and then separated into distinct vertical and horizontal pulses by integration and differentiation. Vertical sync goes to control the timing of the vertical deflection currents and horizontal sync goes to control the timing of the horizontal deflection currents.

The Raster and the Indicator Unit. The deflection currents are generated within the receiver, whether or not an incoming signal is being received. As shown in the flow sheet, these currents are applied to the kinescope deflection yoke. The deflection currents deflect the spot of light on the viewing screen horizontally, tracing lighted lines, and deflect the spot vertically as it traces horizontally. As a result, the spot traces rows of lighted lines from the top to the bottom of the screen. This lighted rectangle is called a raster (Fig. 39-4). The raster can be seen on a television receiver even when no signal is coming in at the antenna, because it is generated within the receiver.

When a signal is received, the sync pulses synchronize the timing of the already present raster lines. At the same time, the picture information contained in the incoming signal is applied to the kinescope grid, where it systematically varies the brightness of the spot that is tracing the raster. In this way, an incoming signal superimposes a picture on the existing raster (Fig. 39-5).

It is possible to think of the kinescope and the deflection circuits as comprising an independent *indicator* unit within the receiver. This indicator unit consists of the kinescope and its associated deflection circuits. It is the part of the television circuit that produces an *indication*, or picture. As shown in Fig. 39-3, the component parts of the refined picture signal — vertical

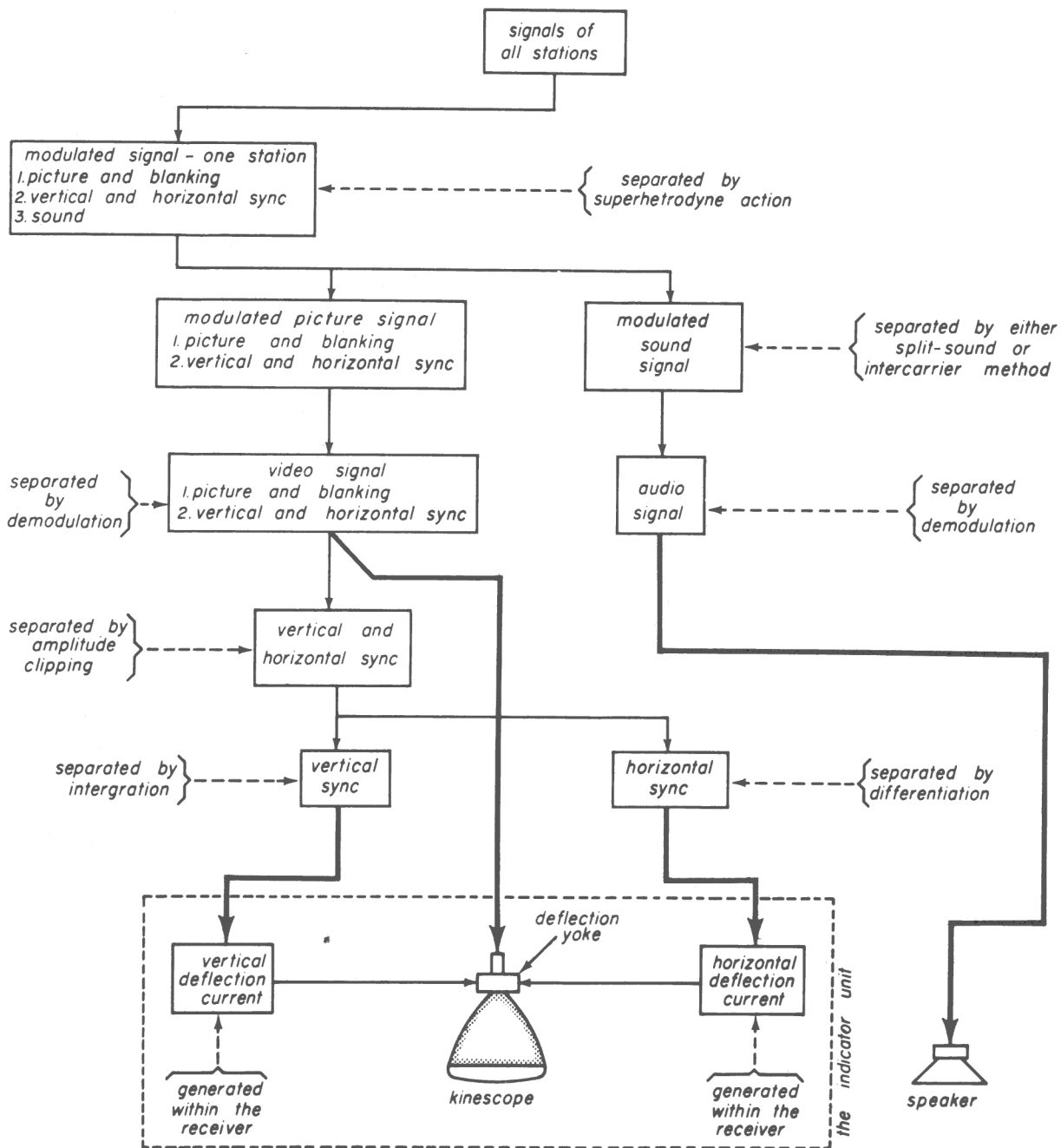


Fig. 39-3

sync, horizontal sync, and picture information—are applied to the indicator unit. Notice the contrast between the kinescope in the picture part of the receiver circuit and another indicator unit, the loudspeaker in the sound part. The loudspeaker is a self-contained indicator unit; it requires no associated circuits to reproduce sound, so the refined sound signal can be applied to it directly. The kinescope must be provided with deflection circuits in order to form an

indicator unit capable of reproducing the picture.

The concept of an indicator unit is helpful when you are analyzing a television receiver schematic. If you have this concept, you separate the receiver into indicator circuits and other circuits. If you know that the indicator circuits are operating properly, you can devote your troubleshooting to other circuits. Indicator cir-

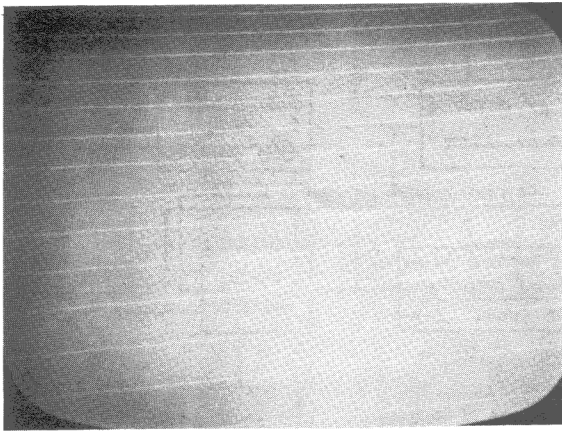


Fig. 39-4

cuits are found in many circuits besides television receivers. For example, indicator units are found in radar circuits, in loran circuits (an electronic navigation system), and in most circuits that employ a cathode-ray-tube indicator.

39.3. SPLIT-SOUND AND INTERCARRIER SOUND RECEIVERS

The television receiver is a superheterodyne receiver. The local oscillator generates an r-f signal, which beats with the incoming picture carrier signal and the sound carrier signal to produce two i-f difference frequencies. The resulting picture i-f signal differs by $4\frac{1}{2}$ mc from the resulting sound i-f signal. In order to separate the sound and picture i-f signals from each other, it is necessary only to have two i-f amplifier chains — one tuned to the picture i.f., and the other tuned $4\frac{1}{2}$ mc lower to the sound

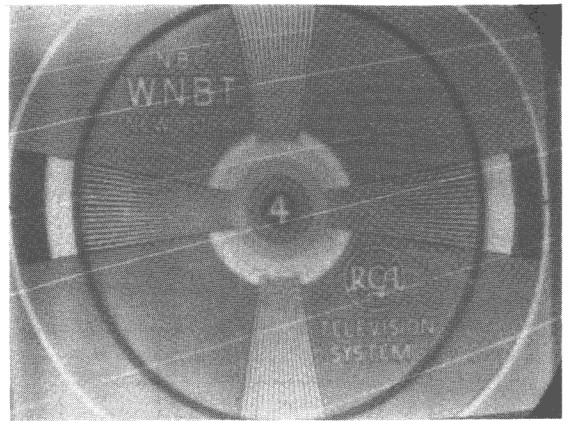


Fig. 39-5

i.f. (Fig. 39-6). This method of separating the picture and sound carriers is called the *split-sound* method. The split-sound method was the first method used in modern television receivers. As shown in Fig. 39-6, when a 55.25 mc incoming picture carrier in Channel 2 beats with the 81-mc local oscillator signal, an i-f picture carrier at 25.75 mc is produced. When the 59.75 mc incoming sound carrier beats with the 81-mc oscillator signal a 21.25 mc i-f sound carrier is produced. Consequently, although the sound carrier is $4\frac{1}{2}$ mc higher than the picture carrier coming in, it is $4\frac{1}{2}$ mc lower than the picture carrier after conversion. The two carriers are amplified in their separate i-f amplifier chains and separately demodulated at the ends of the chains. Because this method has certain disadvantages, it is no longer used.

The *intercarrier method*, in general use at present, is shown in Fig. 39-7. There is no sound i-f strip at the output of the converter of an intercarrier receiver. Instead, both the picture and the sound i-f signals pass

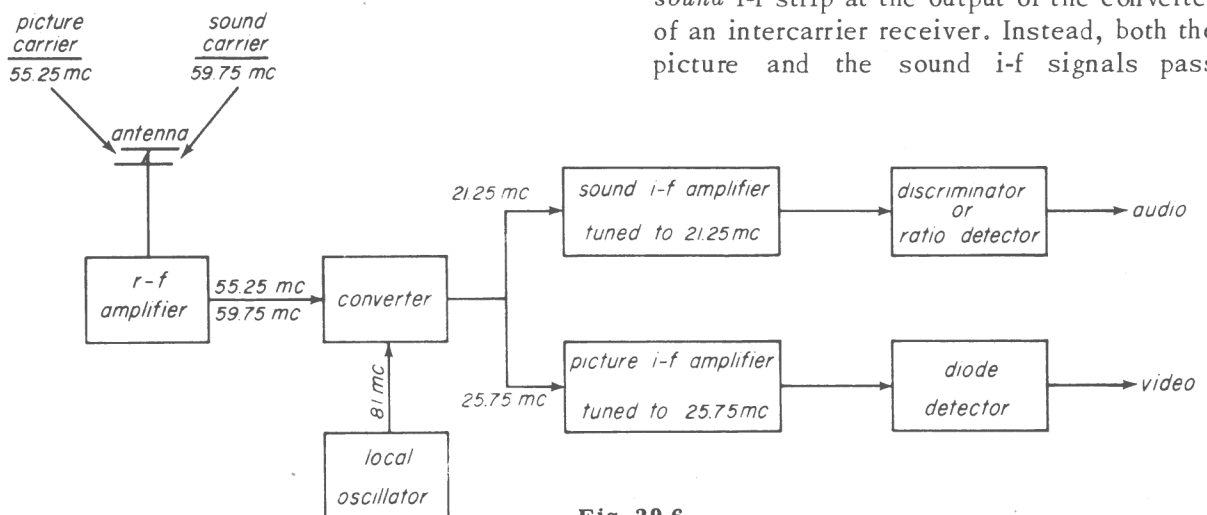


Fig. 39-6

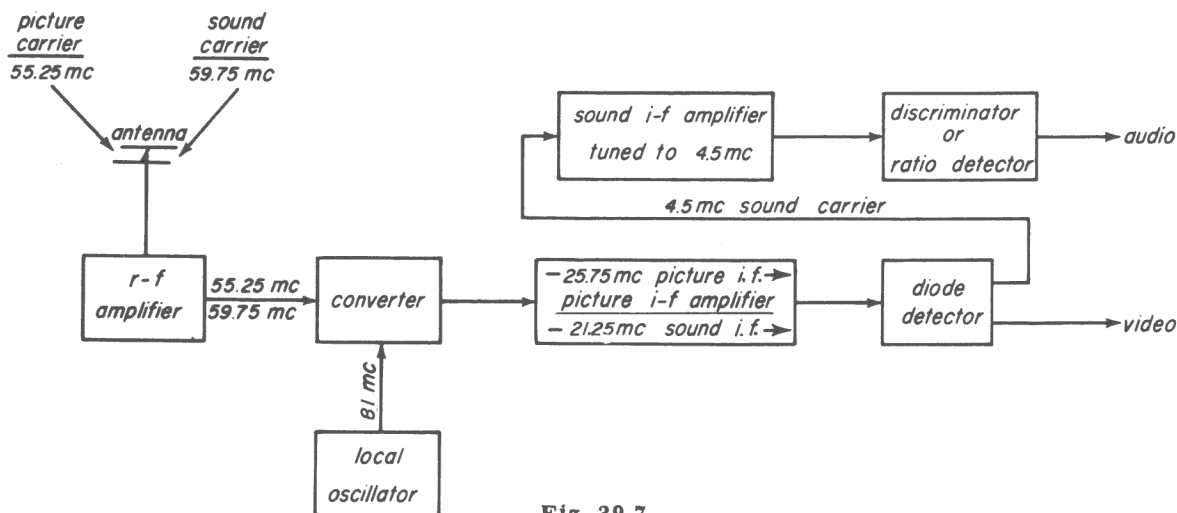


Fig. 39-7

through the picture i-f strip to the picture detector. There, the picture i-f carrier signal is demodulated; the modulation envelope (video) is removed. At the same time, however, the picture detector diode serves to convert — not demodulate — the sound. You know from your study of conversion that when two signals of different frequency are rectified in a diode circuit, they beat together and conversion takes place. In the diode of the picture detector, the FM signal beats with the picture carrier signal — not with a signal from an oscillator. The picture carrier signal fulfills the function of the oscillator. Due to conversion, the $4\frac{1}{2}$ -mc signal results. This $4\frac{1}{2}$ -mc signal is frequency modulated with the sound information. The separate $4\frac{1}{2}$ -mc FM sound signal is passed through a sound i-f strip tuned to $4\frac{1}{2}$ mc and is demodulated at the end of the strip.

Since the picture-carrier fulfills the function of an oscillator for the sound, the picture carrier must always be present for conversion to take place. If the picture-information signal modulating the picture carrier at the TV station were permitted to drive the instantaneous carrier amplitude to zero (during transmission of predominantly white pictures, Fig. 39-1), there would be no picture carrier, and conversion of sound could not take place during that interval. Picture carrier modulation down to zero is avoided, as indicated in Fig. 39-1.

The intercarrier method would not be practicable if the sound were AM rather than FM. The conversion at the picture detector causes

some picture modulation of the $4\frac{1}{2}$ -mc signal; but this is amplitude modulation (AM), and the FM demodulator rejects it. If it did not, the picture signal would be heard as an interfering sound.

39-4. RECEIVER BLOCK DIAGRAM

Now let's consider a block diagram of a television receiver. The block diagram of an intercarrier receiver appears in Fig. 39-8a. Figure 39-8b is an outline drawing of the chassis of an intercarrier television receiver.

Tuning Unit. At the receiver, signals of all channels are intercepted on the television dipole antenna (Fig. 39-9), and all signals are applied together to the receiver. The superheterodyne process takes place and selects the desired channel in the circuits of the r-f amplifier, the converter, and the local oscillator. Unlike corresponding parts and tubes in radio receivers, the component parts and tubes of these circuits in a television receiver are mounted on a subchassis apart from the main chassis, mainly in order to facilitate shielding these circuits. The subchassis is known by several names as follows:

1. The subchassis is sometimes called an *r-f unit*. This name calls attention to the fact that the unit handles the r-f signal. The r-f signal is never present on the main chassis.

2. It is also known as a *tuning unit*. This name emphasizes that all the channel tuning

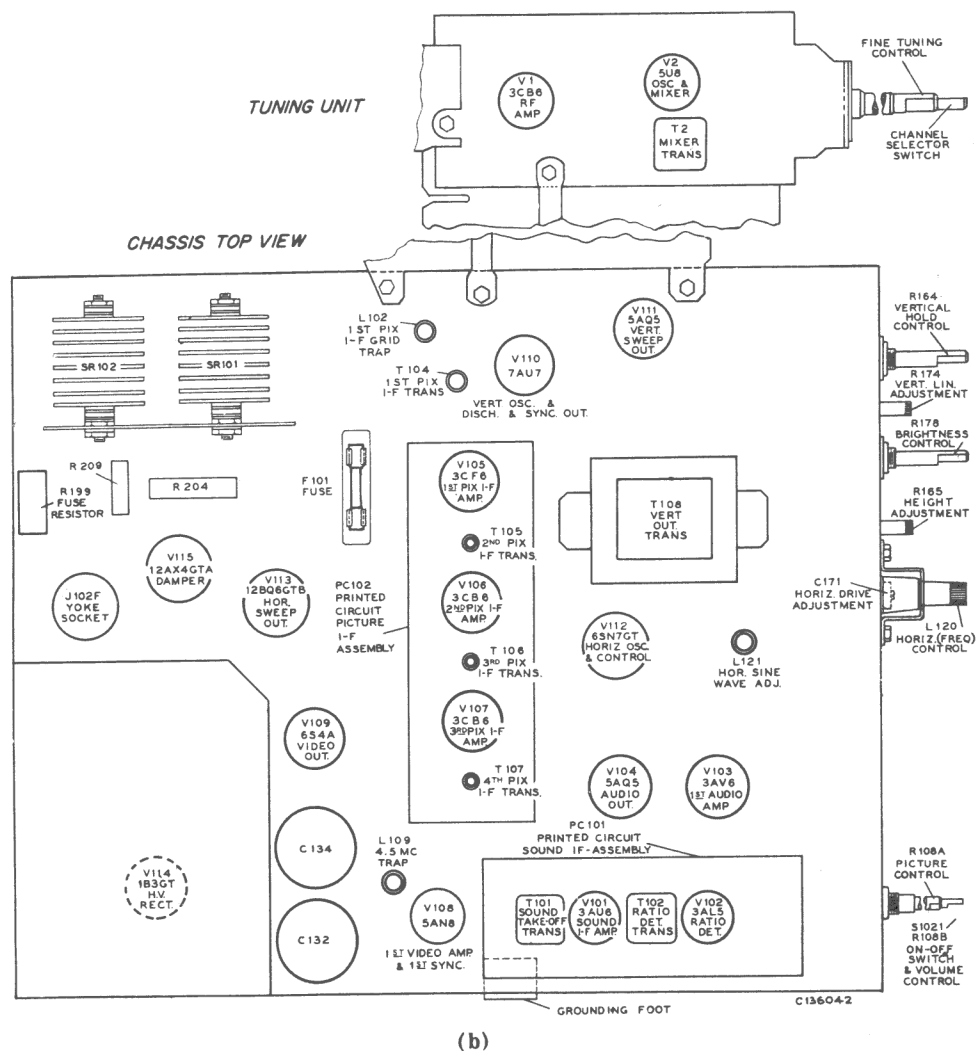
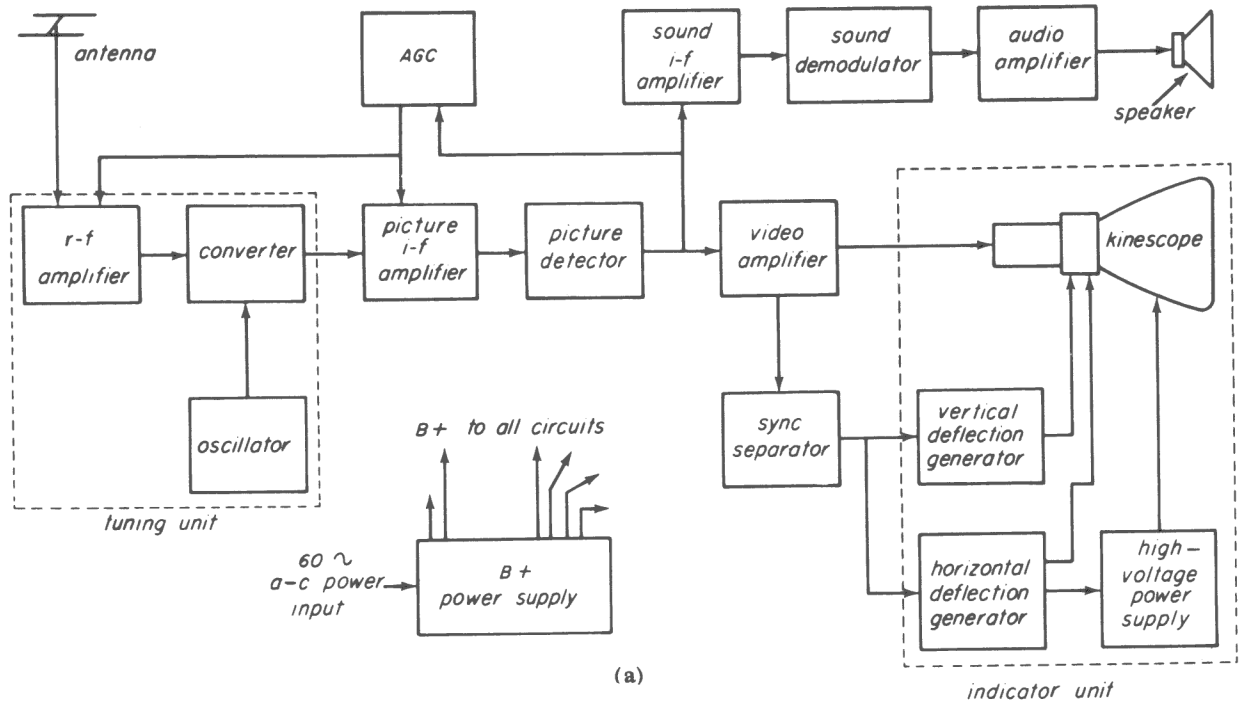


Fig. 39-8

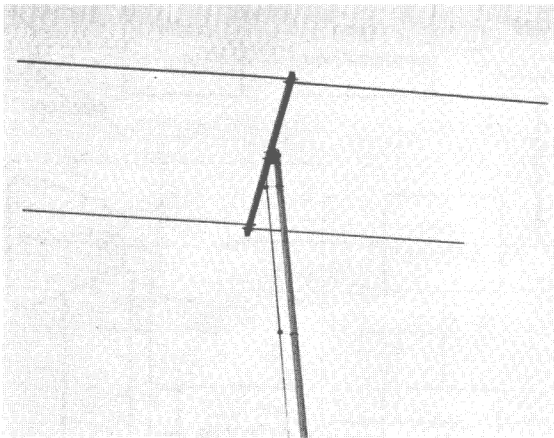


Fig. 39-9

takes place in the unit.

3. It is sometimes called a *front end*, because the incoming signal enters the receiver at the subchassis.

Because the allocated television channels take up a very wide frequency spectrum, tuning of the resonant circuits to select the desired channel is almost always done by switching coils in and out of the circuit — not by rotating an air-dielectric tuning capacitor as with radio. Switching the coils brings the circuits to resonance at approximately the desired frequency. In the case of the oscillator circuit, greater accuracy is needed; oscillator tuning is the controlling factor that determines what station will be selected. The oscillator is provided with a vernier tuning control that usually is a variable solid (not air) dielectric capacitor. The tuning vernier is called a fine tuning control. Miniature tubes are used because they have low interelectrode capacitances and are therefore more suitable for high frequency circuits.

Picture I-F Amplifier. As indicated in the block diagram, the picture and sound i-f carriers go to the picture i-f strip from the converter in the tuning unit. You probably realize that the picture i-f strip consists of a series of tuned amplifier stages. The tuned i-f amplifier differs from the radio kind in several respects. All stages (there are usually three) are not tuned to the same frequency. Instead, the tuning is staggered; each stage is tuned to a different frequency. This is because a graph of the response of a

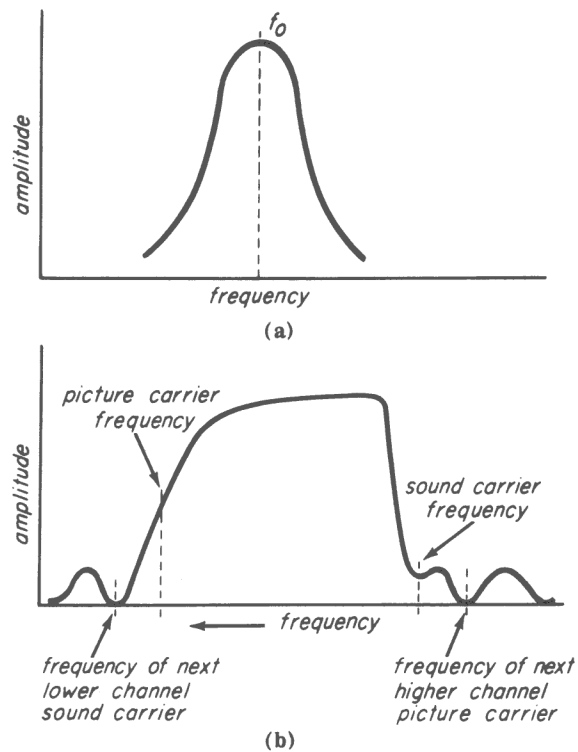


Fig. 39-10

television i-f strip must have a certain standardized shape that at the present time can most readily be produced by stagger tuning. By nature, a tuned amplifier has a response curve that corresponds to the universal frequency response curve of resonant circuits as shown in Fig. 39-10a. This response curve is just right for radio i-f amplifiers. However, the single sideband transmission system used for television requires an i-f response as shown in Fig. 39-10b. The overall television i-f strip has such a response as a result of stagger tuning of the component stages. Each stage has the response of Fig. 39-10a but centered at a frequency slightly different than that of its neighbor. The individual responses combine to produce the required overall response (Fig. 39-10b).

Although television picture i-f stages are tuned amplifiers, the tuned circuit is not usually part of a coupling transformer (Fig. 39-11a) as in radio receivers. Instead the resonant circuit is a simple load impedance in the plate circuit of the i-f tube (Fig. 39-11b). The plate of one i-f tube is coupled to the grid of the next by a capacitor (or some other device for blocking B+). This

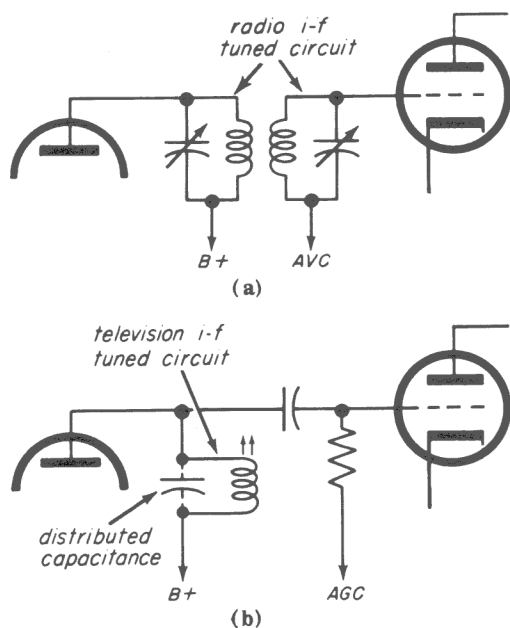


Fig. 39-11

tuning method is known as impedance coupling.

Unlike radio i.f., television i.f. does not make use of a capacitor in the i-f coil assembly. Instead, the inductance of the coil is chosen to be resonant at the required frequency with the distributed capacitance of the circuit.

Television i-f tuned circuits are outfitted with *traps*. These devices are not found in radio i-f circuits. To understand the need for the traps, examine the standardized television picture i-f response curve of Fig. 39-10b. Notice that the curve calls for zero-amplitude response at the frequency of the sound carrier of the next lower television channel and at the frequency of the picture carrier of the next higher channel. The television i-f response is brought to zero at

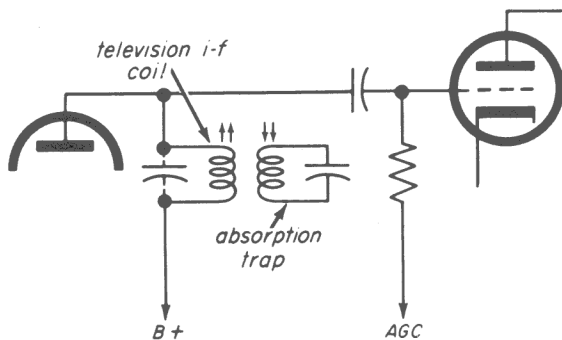


Fig. 39-12

these frequencies by means of traps, which trap out signal at the frequency to be eliminated. One widely used form of television i-f trap is the *absorption trap* shown in Fig. 39-12. This kind of trap absorbs energy from the i-f coil at the resonant frequency of the trap. It does not absorb energy at other frequencies. The absorption trap works by means of magnetic coupling and looks like a part of the magnetically coupled radio i-f transformer of Fig. 39-11a. The difference is that the trap is not connected to anything; the radio transformer is connected to the next stage.

Picture Detector. As indicated in the block diagram (Fig. 39-8a), the detector at the end of the picture i-f strip may fulfill as many as three functions in a television receiver. It demodulates the picture carrier and passes the picture information on to the video amplifier in the form of a video signal. It converts the FM sound carrier to $4\frac{1}{2}$ mc and passes it on to the sound i-f strip. It develops a negative d-c voltage, proportional to signal strength, which is used as a control voltage to regulate r-f and i-f gain. In television, this last process is called *automatic gain control* (AGC). It corresponds to the automatic volume control (AVC) of radio. The sound i-f, sound demodulator, and audio-amplifier blocks have already been discussed.

Video. The word *video* is a substitute for the word *picture* and is derived from the Latin language (just as audio is another word for sound and is also derived from the Latin). The video amplifier (Fig. 39-8a) is a resistance-capacitance amplifier like an audio amplifier. However, the video amplifier must respond to a much wider range of frequencies (nominally 0 cps to $4\frac{1}{2}$ mc) than the range to which audio amplifiers need respond (nominally 0 cps to 20 kc.). A resistance-capacitance amplifier cannot respond to such a wide range of frequencies unless it is specially compensated to avoid the falling-off of response at high frequencies. This falling-off of response is due to the shunting of the load resistor of the amplifier by stray shunt capacitance. (Capacitive reactance decreases as frequency increases.) Compensation in video amplifiers is ac-

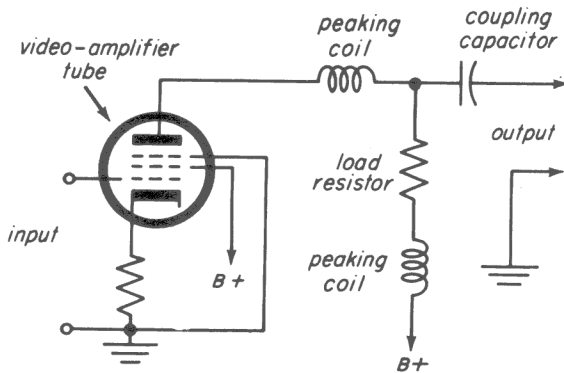


Fig. 39-13

completed by augmenting the plate load resistors with *peaking coils*. The inductive reactance of peaking coils increases with frequency.

A schematic diagram of a video amplifier is shown in Fig. 39-13, which illustrates peaking-coil compensation and shows the location in the amplifier circuit of the coils. Peaking compensation is required in all video circuits whether or not they are amplifiers; i.e., peaking coils are to be found associated with the picture-detector diode-load resistor.

As indicated in the block diagram (Fig. 39-8a), the video amplifier feeds the picture signal and the blanking pulses to the control grid of the kinescope, where they govern the brightness of the moving spot on the viewing screen. Also, the video amplifier feeds the demodulated composite picture signal to the sync separator circuits.

Sync Separator. The sync separator circuits remove sync from the picture and blanking signal and then separate the vertical and horizontal sync pulses from each other. Many forms of sync separator circuits are possible. As an example, let us consider a sync separator built around a basic amplitude clipper. The basic amplitude clipper is shown in Fig. 39-14a. It is an ordinary resistance-capacitance audio amplifier except for two factors; the plate voltage is very low and the grid bias is very negative. As shown in the e_c - i_b curve Fig. 39-14b, the negative bias holds the picture part of the incoming composite video signal below the grid cutoff potential of the tube so that only the sync pulses cause the tube to

conduct and produce an output. Because of the low plate voltage, the peak amplitude of the incoming sync pulses is great enough to drive the tube to plate current saturation; therefore the tops of the sync pulses are squared off in the output. Thus sync is removed from picture signal. As shown in Fig. 39-15a, the output of the clipper is fed simultaneously to an integrator network and to a differentiator network. Both consist of a resistor in series with a capacitor.

Integrators can be identified by the fact that the output is taken across the capacitor. The value of the capacitor with respect to the resistor—that is, the RC time constant—is such that the capacitor does not have time to charge to the full voltage amplitude of the horizontal pulses during the short time duration of these pulses. As a result, the horizontal pulses cause very little output from the integrator (Fig. 39-15b). But the capacitor has time to charge to the amplitude of the vertical pulse, which lasts much longer. Therefore, when there is a vertical pulse at the input to the integrator there is a considerable output from the integrator.

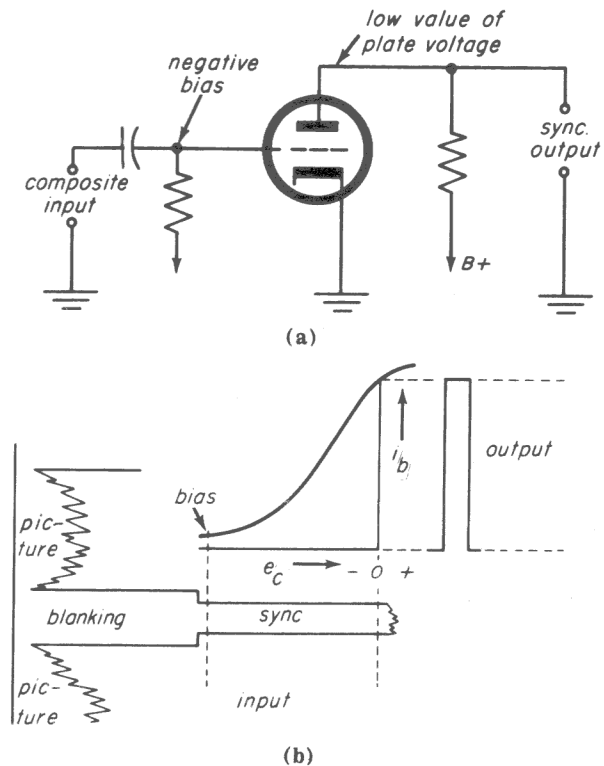
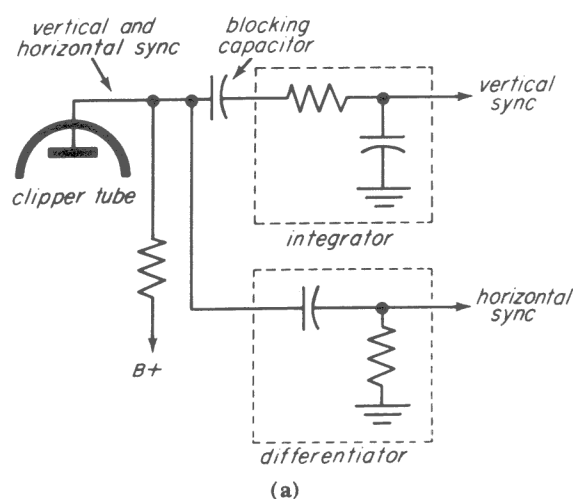
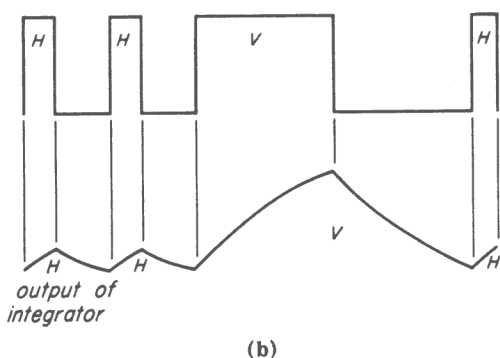


Fig. 39-14



sync output
of clipper



sync output
of clipper

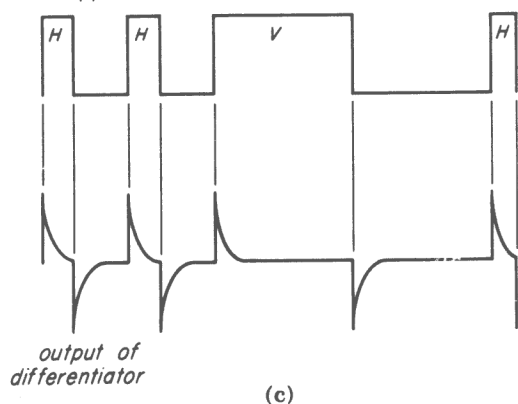


Fig. 39-15

A differentiator can be identified by the fact that output is taken across the resistor. The value of the capacitor is small so the circuit responds to any rapid change of input voltage level. The rapid rise of voltage level at the start of a horizontal pulse causes a sharp pulse of voltage to occur across the output resistor of the differentiator (Fig. 39-15c), as does the rapid drop

of voltage level at the end of the sync pulse. Thus a sharp positive-going and a sharp negative-going pulse appear at the output of the differentiator for every horizontal sync pulse that occurs at the differentiator input. (Some horizontal deflection generators require an unaltered horizontal pulse for synchronization. The horizontal sync separator that provides it does not alter the pulse.)

The rapid rise of voltage level at the start of a vertical pulse also causes a sharp pulse of voltage to occur at the output of the differentiator. Immediately after this, the input voltage level remains at the peak amplitude of the vertical pulse during the long time duration of the pulse. During this time, the output of the differentiator is zero. At the end of the vertical pulse, the input voltage level falls rapidly to zero. This causes another sharp output pulse of opposite polarity to the first. Thus, the long vertical pulse does not appear as such at the output of the differentiator.

We have discussed only the basic principle underlying the response of a differentiator to the vertical pulse. A full description would take account of the serrations (not shown) in the pulse and also the equalizing pulses.

The Indicator Unit – Vertical Deflection.

The indicator unit is not a physical unit such as the tuning unit subchassis. Instead, it is a set of receiver circuits, which are usually grouped together so that a person studying or servicing television receivers can visualize how television receivers work. Actually, the circuits of the indicator group may be distributed at random throughout the chassis wiring. The block diagram (Fig. 39-8a) shows that the isolated vertical sync pulse from the sync separator is fed to the vertical deflection generator in the indicator unit. Vertical deflection generators create a sawtooth of current that recurs sixty times per second (the field repetition rate) when the generator is synchronized. The basic schematic diagram of a vertical deflection generator is shown in Fig. 39-16. The vertical deflection signal originates in the vertical oscillator. It is a blocking oscillator, and its

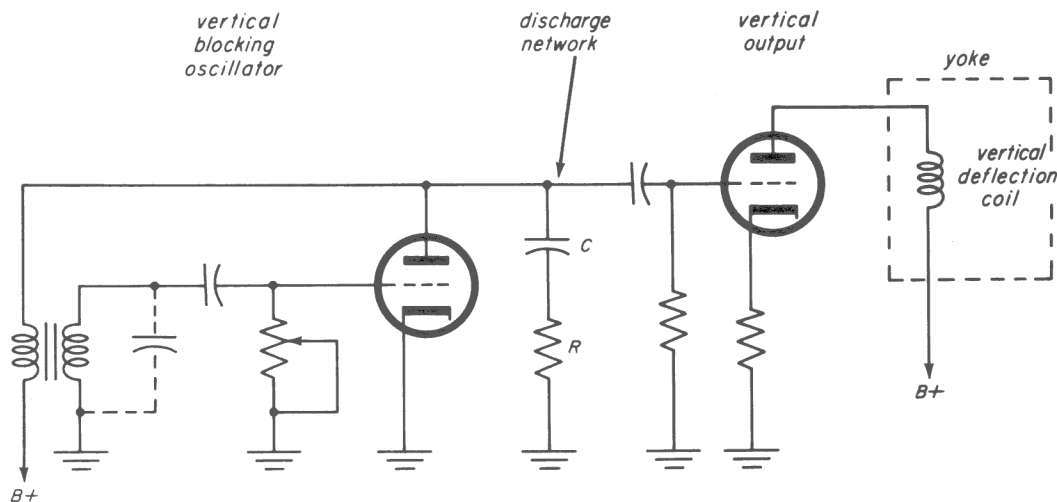


Fig. 39-16

natural output waveform is a narrow pulse of voltage recurring sixty times per second. However, because of the RC combination connected from plate to ground across the output, the circuit actually delivers a sawtooth of voltage. This is shown graphically in Fig. 39-17. When the sharp output pulse natural to the circuit occurs, it rapidly discharges the capacitor C (which is charged to $B+$ while the circuit is at rest); plate voltage drops abruptly. Then — during the interval of time until the next sharp pulse — the capacitor gradually charges and forms a gradually rising voltage at the oscillator plate. The gradually rising voltage corresponds to the wide slope of the sawtooth waveform, and the abrupt drop in voltage corresponds to the narrow slope of the sawtooth waveform. Thus the natural narrow pulse output of the oscillator becomes a sawtooth of voltage when the capacitor C is in place. R and C are called a *discharge network* or a *sawtooth network*. (You may have observed that the circuit works something like the thyatron sawtooth generators described in the lesson on oscilloscopes.)

The output waveform is a modified kind of sawtooth, more accurately called a *trapezoidal* waveform. However, the trapezoid is a *voltage* waveform; a sawtooth of *current*, not voltage, is required in the vertical deflection coil of the kinescope yoke. The sawtooth of current occurs in the vertical coil when the trapezoidal voltage waveform is applied to the control grid of the vertical output tube — a power amplifier tube with the vertical coil as plate load.

Let's briefly consider how a blocking oscillator produces narrow output pulses in its plate circuit. The oscillator is a tickler feedback (Armstrong) circuit. The tuned circuit is the grid winding of the feedback transformer, resonant with its distributed capacity (Fig. 39-16) at a relatively high frequency. The circuit would oscillate at the resonant frequency of the grid coil, except that so much signal voltage is fed back that it blocks. So great is the feedback that the oscillator blocks after one-half cycle of oscillation at the resonant frequency. The half cycle of high-frequency sine wave is the narrow pulse that has been identified as the natural output waveform of the blocking oscillator (Fig. 39-17). The time required for the circuit to recover and produce another pulse is determined by the time required for the grid coupling capacitor to discharge through the grid leak resistor and thus relieve the grid of high negative bias. This

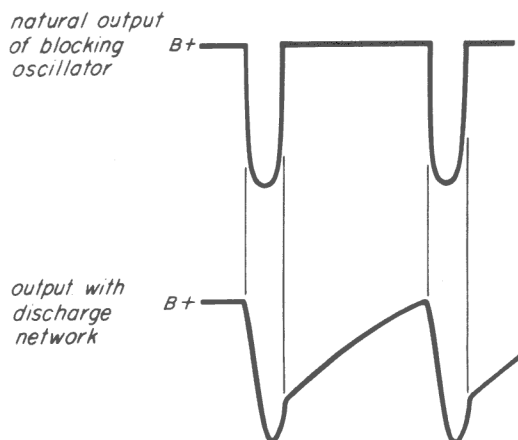


Fig. 39-17

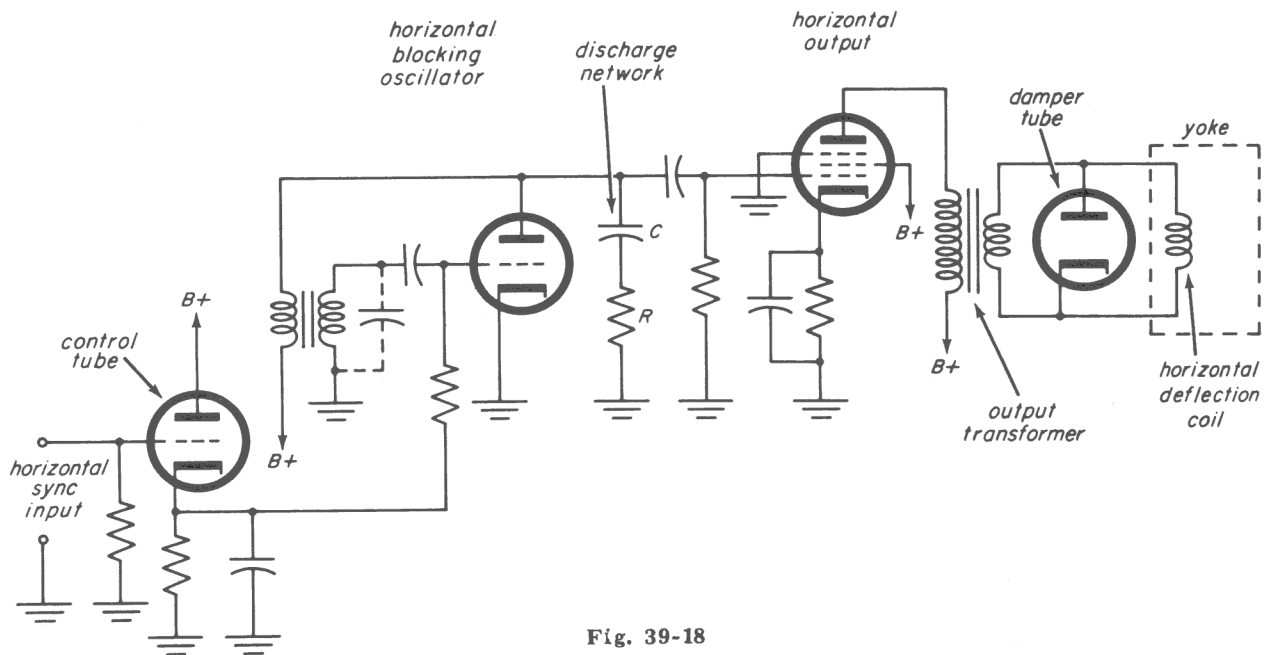


Fig. 39-18

time is fixed by the RC time constant of the grid capacitor and resistor. Thus, the RC time constant of the grid circuit determines the pulse repetition frequency and, consequently, the sawtooth frequency. The sawtooth frequency can be adjusted by varying the value of the grid resistor. When the vertical sync pulses are applied to the grid of the oscillator, they cause the grid capacitor to discharge ahead of time, thereby causing the pulse to repeat before it would without sync. Thus, sync controls the sawtooth frequency of the oscillator.

The Indicator Unit – Horizontal Deflection. The horizontal deflection generator circuit (Fig. 39-18) of the indicator unit is, like the vertical circuit, basically a blocking oscillator, discharge capacitor, and output tube. In addition, an oscillator control circuit (another electron tube) is associated with the oscillator. This improves synchronization of the oscillator. Also, the sawtooth of current in the horizontal coil of the yoke is not entirely the direct result of the sawtooth voltage applied to the output tube from the oscillator. The sawtooth voltage starts the current flowing and starts the spot moving horizontally on the viewing screen. But the sawtooth voltage ceases before the moving spot has traced a full horizontal line, while the current in the coil continues of its own momentum and the spot

continues to move. To stop the current at the time the spot has completely traced a line, a second additional tube, called a *damp*er tube, is employed in the horizontal deflection circuit.

As you see, the horizontal scanning generator circuit is an altered version of the more basic vertical circuit. This altered version of the basic circuit is known as a *reaction scanning circuit* or *flyback circuit*. Its advantage is improved efficiency. It is used because very large output tubes would be necessary to provide adequate width of horizontal deflection if the less efficient basic circuit were employed – especially since wide-screen (up to 27 inches) kinescopes are in use.

Horizontal sync is applied to the oscillator control tube in the horizontal circuit. In the rudimentary circuit shown in Fig. 39-18, horizontal sync signal varies conduction in the control tube and therefore varies the voltage drop across the cathode resistor. Voltage developed across the cathode resistor of the control tube is applied as bucking bias to the grid of the oscillator. The positive voltage from the control tube cathode bucks and partially cancels the negative signal bias on the oscillator grid. Thus, the voltage from the control tube alters the frequency of the oscillator by

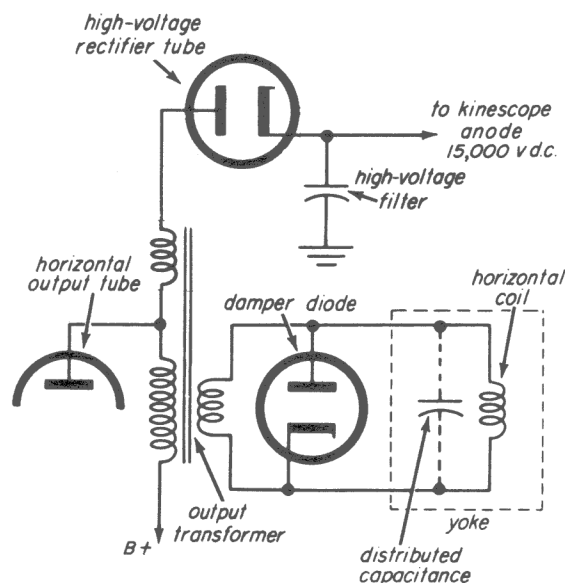


Fig. 39-19

altering the net grid voltage of the oscillator.

The Indicator Unit – High-Voltage Supply.

Kinescopes require an anode voltage that is in the neighborhood of 15,000 volts in order to attract the cathode-ray beam. The circuit used to supply this d-c potential (Fig. 39-19) is a part of the indicator group of circuits. The high-voltage supply circuit works in conjunction with the horizontal output circuit. In order to explain the high-voltage circuit, let's go back to where we left off in our discussion of the horizontal output circuit. As we pointed out, current continues in the horizontal coil of its own momentum, once it is started. The voltage waveform that starts current flowing in the horizontal coil of the yoke actually shocks the coil into oscillation at the natural resonant frequency of the coil and its distributed capacitance. The oscillating yoke coil would continue to produce an alternating current until oscillations died out, were it not for the damper tube rectifier, which stops the oscillation within the time of one cycle. As the spot finishes tracing a line, the first voltage cycle of shock-excited oscillations is just beginning to reverse polarity. The polarity in which the voltage across the yoke is beginning to rise at this instant is such as to cause the damper diode to conduct. During conduction, the tube has a low internal resistance. During the unwanted part of the cycle while the tube con-

ducts, the tube is a short circuit across the yoke coil; therefore it damps out the unwanted cycles of oscillation.

The part of the cycle of yoke oscillation that is not damped completes horizontal deflection of the spot to finish scanning a line on the viewing screen. While the wanted part-cycle of self current of the yoke is flowing, it causes a low-amplitude pulse of voltage to occur across the yoke coil. The coil is across the secondary winding of the step-down output transformer. Thus, the yoke-generated pulse is applied to the transformer in reverse. To the voltage pulse, the secondary winding becomes a primary winding and the transformer becomes a step-up transformer. The low-voltage yoke pulse induces a high-voltage pulse on the normally primary winding of the transformer. It is only necessary to rectify and filter this voltage to obtain the 15,000 volts d.c. kinescope anode voltage.

39-5. THE RECEIVER RELATED TO THE VIEWING SCREEN

We have related the television receiver to the incoming signal. It is also possible to relate the receiver to the visible presentation on the face of the kinescope. To a television serviceman, the viewing screen is a window on the inner workings of the receiver. For example, if the serviceman sees a single bright horizontal line (Fig. 39-20) on the screen where the picture should be, he knows that the vertical deflection generator is not working. He knows that, relative to the viewing screen, it is the function

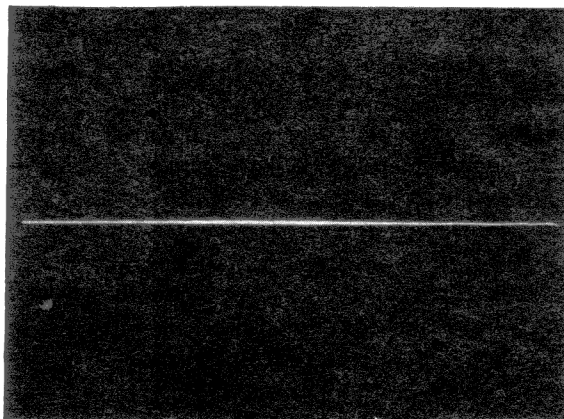


Fig. 39-20

of the vertical deflection generator to spread the picture vertically.

However, the receiver relationship to the screen is not always as direct as that in our example. Also, minute details of the visible presentation indicate faults in small subdivisions of large circuits like the vertical generator. We will limit our discussion to the large subdivisions of the receiver.

In examining a new model television receiver, the television serviceman *pulls tubes*. He removes the tubes one at a time and carefully observes the visible effects. This procedure is not followed in radio, where there are comparatively few tubes and their function is much the same from model to model. But it is followed in connection with other circuits, not only in television work but in most service work involving many-stage electronic devices.

You might think that removing the horizontal oscillator tube results in a single vertical line just as removing the vertical oscillator tube results in a single horizontal line. This would be so if the high voltage circuit did not work in conjunction with the horizontal deflection generator. Pulling the horizontal oscillator shuts off the 15,000-volt d-c (approx) kinescope anode voltage. The screen goes black. Sound, of course, continues.

If the low-voltage (B+) rectifier is removed, the screen goes black; also sound ceases because all the receiver circuits are deprived of B+ power.

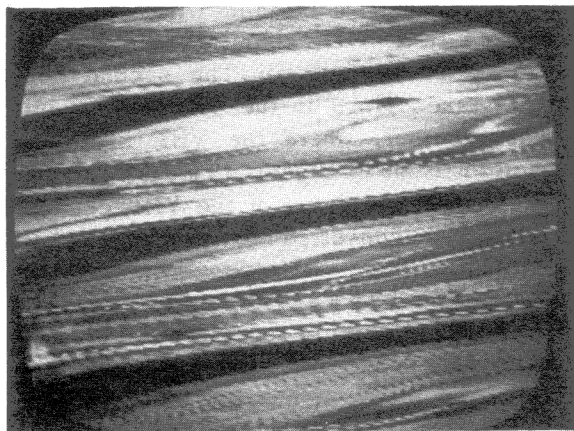


Fig. 39-21

If the horizontal oscillator control tube is removed, the horizontal scanning lines are no longer synchronized with the camera back at the television station. As a result, the brightness variations of the moving spot of light do not occur in their proper place on the viewing screen. The picture seems to tear apart horizontally (Fig. 39-21).

All television receivers do not work in exactly the same way. Figure 39-22a is a reproduction of part of the block diagram shown earlier in this lesson. According to this diagram, the sync pulses from the sync separator are applied directly to the deflection generators. However, some receivers are arranged as at b. The separated vertical sync pulses are fed to a vertical sync amplifier before being fed to the vertical deflection generator. Removing the vertical sync amplifier tube unsynchronizes the vertical deflection generator but has no other visible effect. Vertical nonsynchronization causes the screen with the picture on it to seem to drift up or down past the viewing aperture in the receiver cabinet (Fig. 39-23). In the arrangement at Fig. 39-22a, there is no electron tube that handles only vertical sync pulses. The visible effect of vertical nonsynchronization cannot be caused by removing a tube with the arrangement as at a.

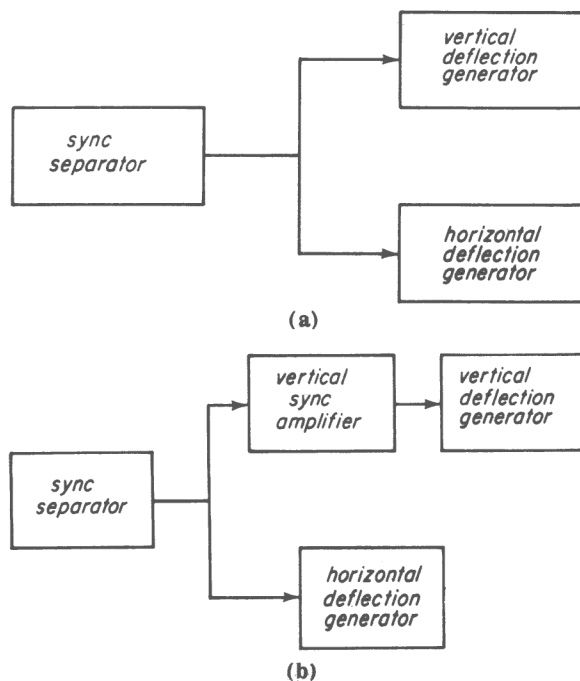


Fig. 39-22

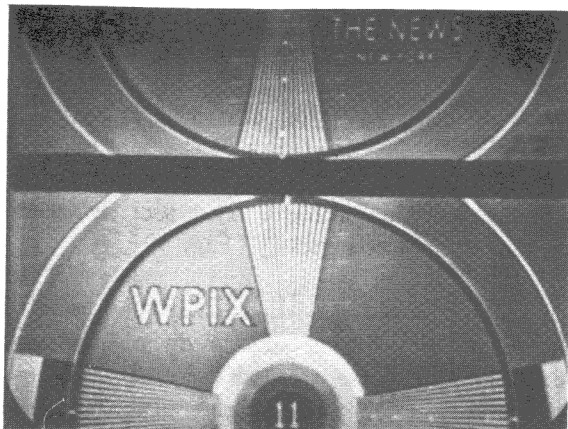


Fig. 39-23

If the sync separator tube is removed, the effect is a combination of vertical and horizontal nonsynchronization. Removal of any tube in the picture amplifier chain that extends from the r-f amplifier, through the i-f strip, to the video output tube (connected to the picture tube) results in no picture; the lighted rectangular raster remains.

39-5. UHF RECEIVERS

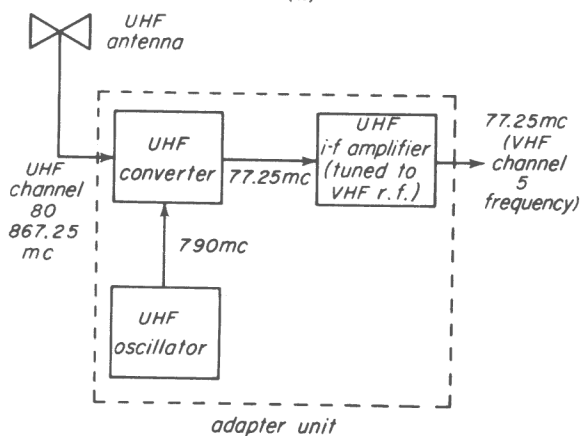
All television receivers are designed to pick up VHF channels. Some are designed to also pick up the higher frequency UHF channels. In addition, receivers designed for only VHF reception can be adapted to receive UHF channels.

The circuit differences between receivers that pick up UHF channels and those that do not are in the front end (tuning unit). The same i-f strip is used for processing both VHF and UHF signals. Two different front-end processes are in use for reception of UHF channels.

1. Adapter units like the one pictured in Fig. 39-24a take in a UHF channel, and, by the superheterodyne process, convert it to a VHF channel. For example, the adapter might pick up UHF channel No. 80 in which the picture carrier is at 867.25 mc. As shown in the block diagram, Fig. 39-24b the local oscillator in the adapter runs at 790.00 mc when the adapter is set to receive UHF channel 80. The 790.00-mc oscillator signal beats with the 867.25-mc channel 80 picture carrier to produce a 77.25 mc difference fre-



(a)



(b)

Fig. 39-24

quency signal containing the picture modulation of channel 80; and 77.25 is the picture carrier frequency of VHF channel 5. Therefore, in order to see the picture, the output of the adapter can be applied to the antenna input of a VHF receiver tuned to channel 5.

This process is called *double conversion*. The first conversion takes place in the adapter unit where the UHF signal is converted to a VHF signal (channel 80 is converted to channel 5). The second conversion takes place in the VHF tuning unit in the receiver, where the VHF signal is converted to an i-f signal. For example, the 77.25-mc picture signal of the VHF channel 5 might be converted to a 45.75-mc i-f signal.

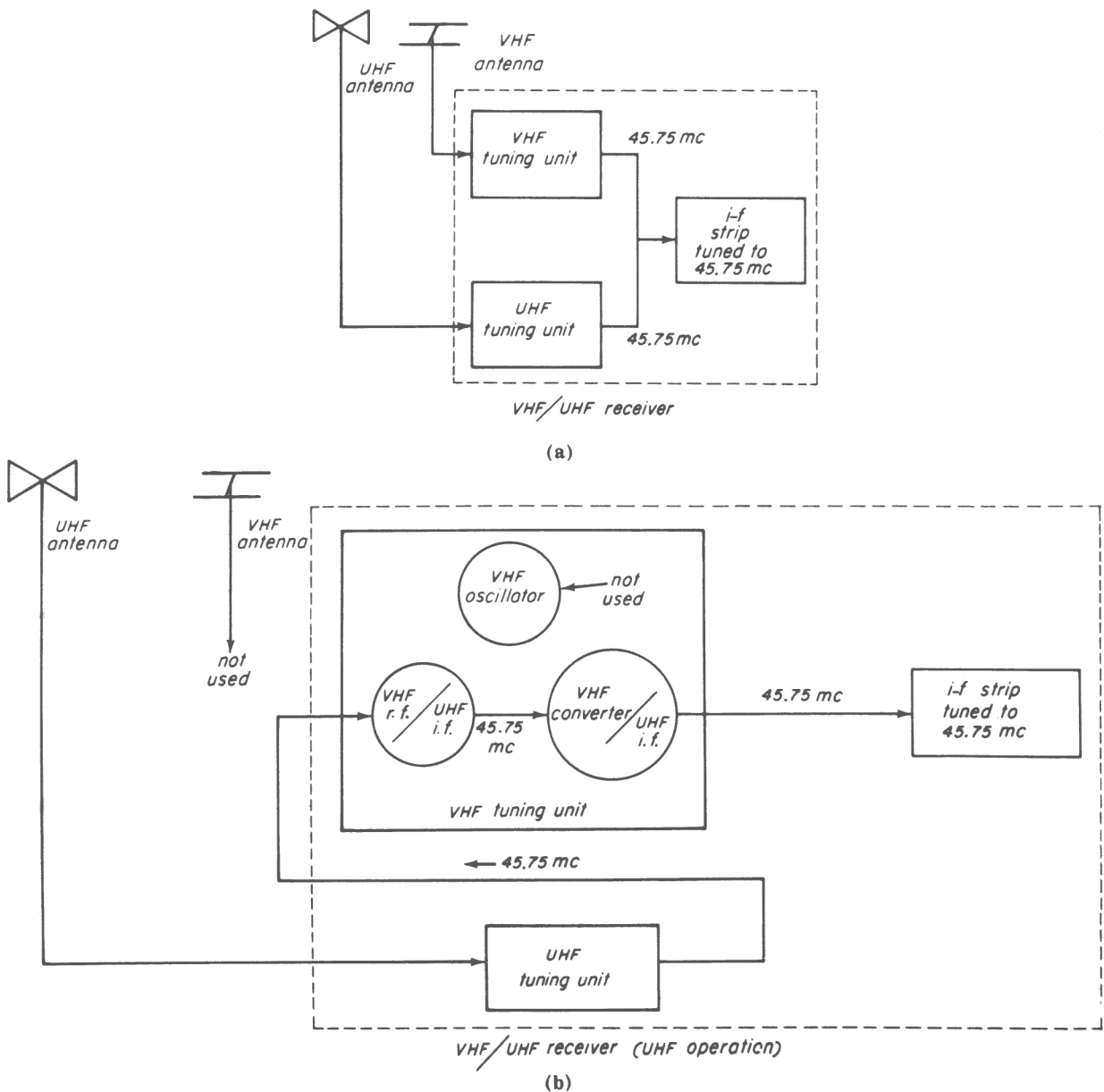
2. Some television receivers designed to receive both VHF and UHF have two separate tuning units — one for UHF and one for VHF. The block diagram of Fig. 39-25a shows how this method works. A single i-f

strip serves for either the VHF front end or the UHF front end, depending upon which kind of signal is being received. Double conversion does not occur. Instead, when a UHF signal is to be received, it is heterodyned in the UHF tuner and converted to 45.75 mc for amplification in the common i-f strip. When a VHF signal is to be received, it is heterodyned in the VHF tuner and also converted to 45.75 mc for amplification in common i-f strip.

The expanded block diagram Fig. 39-25b shows a practical modification of the basic process just described. When a UHF signal

is being received, the tubes in the VHF tuner do not go to waste. The tuned circuits of the VHF r-f amplifier and converter are switched to 45.75 mc and they are added as additional amplifiers to the common i-f strip, thus improving receiver gain for UHF. Only the VHF oscillator tube is not utilized in UHF operation. (Added receiver gain is needed for reception of UHF signals.) When VHF signals are received, the UHF front end is not utilized in any way.

There are variations of this method. Sometimes the UHF and VHF tuning units have a common shaft for a single front-panel



station-selector control. Sometimes there are two station selector controls. In another variation, the two separate front ends are built into a single tuning unit subchassis assembly. The stages of such a combined assembly are as follows:

1. A VHF oscillator stage
2. A UHF oscillator stage
3. A combination VHF r-f amplifier/UHF i-f amplifier stage
4. A UHF converter
5. A combination VHF converter/UHF i-f amplifier stage

